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NUMERICAL ANALYSIS OF BLAST PRESSURE PARAMETERS ON THE BUILDING WITH AND WITHOUT WALL AS A BARRIER

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

_____

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ABSTRAK

Beban letupan mungkin disebabkan oleh peledakan bahan peledak yang tinggi dan bahan kimia. Terdapat banyak peristiwa letupan yang berlaku berhampiran bangunan yang meletup sama ada kerana keganasan atau kemalangan. Ini kerana bangunan dan infrastruktur yang dibina di kawasan awam tidak direka untuk menahan beban letupan. Oleh itu, adalah penting untuk mempertimbangkan beban letupan dalam reka bentuk bangunan. Tidak ekonomikal dan realistik untuk reka bentuk bangunan dengan rintangan letupan penuh. Sekiranya beban letupan di atas bangunan, ia akan bertindak balas berbeza berbanding dengan beban biasa. Oleh itu, simulasi akan dilakukan untuk melihat profil tekanan letupan pada bangunan. Kajian ini dilakukan untuk menilai profil tekanan letupan pada keadaan dengan dinding dan tanpa dinding. Beban letupan dengan 13.6 kg (30 lbs.) Trinitrotoluena (TNT) akan digunakan dan akan disahkan dengan artikel untuk membandingkan model 3D berangka dengan uji eksperimen sebelum ia boleh digunakan untuk parameter lain. Dalam analisis berangka ini, 3 situasi akan dipertimbangkan. Pertama, letupan di ruang terbuka. Untuk letupan kedua dan ketiga di sebelah bangunan tanpa dan dengan kehadiran dinding RC sebagai penghalang masing-masing. Simulasi ini akan dilakukan menggunakan perisian ANSYS AUTODYN. Daripada simulasi, ia menunjukkan bahawa tekanan yang tinggi pada 18 kaki hampir sama dengan tekanan yang tinggi dari artikel oleh Yan et. al (2011). Untuk Yan et. al (2011) beban tekanan lampau adalah 494.4 kPa pada 4.64 msec dan beban tekanan lampau untuk medan bebas pada 18 kaki adalah 494.4 kPa pada 4.62 msec. Untuk membina dengan kehadiran tekanan letupan RC RC boleh mengurangkan kira-kira 120%. Beban tekanan lampau pada jarak henti 1219 mm (4 kaki) tanpa dinding adalah 1255.63 kPa pada 0.22 msec, manakala beban tekanan lampau dengan dinding berkurangan kira-kira 315.24 kPa pada 1.66 msec pada jarak kebarangkalian yang sama (1219 mm). Hasil keseluruhan menunjukkan bahawa dengan kehadiran dinding RC, tekanan overpressure dapat dikurangkan. Hasil berangka menunjukkan bahawa dinding RC boleh digunakan sebagai halangan untuk mengurangkan tekanan overblur.

ABSTRACT

Blast loading may result from the detonation of high explosives and chemical ammunitions. There are many blast event occurred near the building that explode either because of terrorism or accidental. This is because the building and infrastructure construct in civilian area are not design to withstand the blast load. Therefore, it is important to consider blast loads in design a building. It is not economical and realistic to design building with full blast resistance. In the event of blast load on building, it will react differently compared to normal load. In this paper, simulation will be done to observe blast pressure profile on building. This research was done to evaluate the blast pressure profile at situation with and without wall. Blast load with 13.6 kg (30 lbs.) Trinitrotoluene (TNT) will be used and will be validated with an article to compare the numerical model 3D with experimental test before it can be used for others parameters. In this numerical analysis, 3 situations will be considered. First, the blast in open space. For the second and third, blast next to the building without and with the presence of RC wall as barrier respectively. The simulation will be done using ANSYS AUTODYN software. From the simulation, it shows that the peak blast overpressure at 18 ft. is almost same with peak blast overpressure of article by Yan et. al (2011). For Yan et. al (2011) the peak blast overpressure is 494.4 kPa at 4.64 msec and peak blast overpressure for free field at 18 ft. is 494.4 kPa at 4.62 msec. For building with the presence of the RC wall blast pressure can be reduce about 120%. The blast peak overpressure at standoff distance 1219 mm (4 ft.) without wall is 1255.63 kPa at 0.22 msec, while the blast peak overpressure with wall is reduced about 315.24 kPa at 1.66 msec at the same standoff distance (1219 mm). The overall result show that with the presence of RC wall, the blast overpressure can be reduced. The numerical result show that RC wall can be used as barrier to reduced blast overpressure.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

Y_c (p^*)	compressive meridian
$F_{elastic}$	ratio of the elastic strength to failure surface strength
F_{cap} (p)	function that limits the elastic deviatoric stresses
B	the residual failure surface constant
M	residual failure surface exponent
D_1 and D_2	material constants for effective strain to fracture
$G_{fracture}$	shear modulus
$G_{elastic}$	shear modulus
$G_{residual}$	shear modulus
ε_p	effective plastic strain
T_{room}	room temperature
T_{melt}	melting temperature
γ	ratio of specific heat
ρ	air density
E_i	specific internal energy
P	detonation point pressure
σ^*	strength of glass
σ_i^*	normalized intact strength
σ_f^*	normalized fracture strength
D	damaged scalar

LIST OF ABBREVIATIONS

ALE	Arbitary Langrangian Eulerian
FE	Finite Element
ft	Feet
JWL	Jones-Wilkins-Lee
JC	Johnson and Cook
Kg	Kilogram
lbs	Pound weight
m	Meter
mm	Mili meter
msec	Mili second
MPa	Mega pascal
psi	Pound per Square Inch
RC	Reinforced Concrete
TNT	Trinitrotulene

CHAPTER 1

INTRODUCTION

1.1 Research Background

Blast loading may result from the detonation of high explosive, gas leakage and chemical ammunitions. The force from blast explosion us extremely high, where the force applied over short period of time contrary from normal load. For example, the surfaces of a table and box cannot exert normal forces if both not in contact with each other. Damage to surrounding area such as building damage, collapse and loss life from the epicentre of the explosion cannot be avoided when it occurred. Blast at nearby building are the most reported, either in the war zone or blast due to terrorist attack (Hadden et. al,2007). However, some technic and method for precaution can be used to minimise the impact. Therefore, it is important to understand the blast overpressure behaviour when it next to the building and possible impact from it can be deduce.

The study on the blast effect on structure come to interest due to the attack on the Alfred P.Murrah Federal Building in Oklahama City on 19 April 1995 (Shih-Ho,2016). According to P.Murrah Federal Building the event occur in front of the nine-story because of the truck explosion that set-off by anti-government militant next to the building and about half of the building collapsed (Gumbel,2015). To design building that can fully resist blast load is not realistic and economically. However, with new method and technology, the blast impact on the building or surrounding area can be reduced. One of the effective approach to ensure the safety and reduced the blast impact on the civilian nearby or inside the building is by construct a wall as barrier (Shi,2016).

1.2 Problem Statement

Nowadays explosion event not just occur at war zone, but also reported at civilian area especially at attraction places. This categorised as terrorist attack. The purpose normally to get attention from the authority or want the government fulfil the request. When the explosion occurs at such places, most of the surrounding area including vehicle, building and people are defendless against blast load. The fatal injury and damage on the surrounding are higher in this event. Besides, civilian structure and infrastructure are not design to withstand this kind of load. Therefore, it is necessary to evaluate the blast pressure profile at this situation with and without wall barrier as the protection method. It also necessary to observe blast wave when there is people inside the building. The intensity of this type of load on the building without the wall and wall protection as a barrier need to be assessed. The purpose of this study is to observe the blast profile of buildings with the wall and without wall. Besides that, this study was conducted to know the effect of blast on human inside of the building when there is explosion occur near the building. Other than that, to observe the blast pressure inside and outside of the building when blast happen. In this study, it will focus on the reinforced concrete (RC) wall as barrier at residential area. Numerical analysis will be conducted in three possibility situation which are first with wall, second without next to the building as barrier and the distance of wall with building.

1.3 Objective

The aim of this study was to use RC wall as barrier due to constraint space such as residential area, commercial area and utilities building that developed just next to traffic access such as road, highway and railway station. Hence, the objective of this study are :

- To investigate the blast pressure parameter from 30 lbs. Trinitrotoluene (TNT)
- To study the blast pressure profile on building with wall and without wall as barrier
- To observe the possible effect of blast pressure on human inside the building.

1.4 Scope of Study

In order to achieved the above objective for this research, the scope of this research must be follow as below :

- Numerical modelling of 30 lbs. TNT must be done in ANSYS AUTODYN 3D FE. The experimental result by Yan et. al (2011) will be used to validate the numerical blast pressure of 30 lbs. TNT.
- The numerical analysis would be done on building without RC wall as barrier and building with RC wall as barrier
- The possible impact on human in the building due to blast pressure.

1.5 Significance of Research

This research required to do the simulation in 3-dimensional (3D) numerical model of blast with 13.6 kg (30 lbs. TNT). The blast is modelled and then will be validated by an article reported by Yan et. al (2011) before it can be applied to other parameters. The numerical 3D model is used as reference to the real test.The 3D numerical blast of 30 lbs TNT subjected to building with RC wall and building without RC wall are developed using ANSYS AUTODYN. Therefore, numerical study on blast pressure parameters is possible since civilian researchers had limited access to conduct actual blast test on site. In addition, from the numerical result, further understanding on the possible damaged can be predicted.Besides that, this research is very helpful and beneficial in construction industry since building design in civilian area are not design to withstand the blast. So, this study can be implemented in new invention to developed and construction of the building.Furthermore, this research is very helpful to study on blast load effects and possible damage such as damages on building, infrastructure, injury on human and fatality can be predicted due to the understanding of the pressure parameters numerically and literature review that can provide more information in this research.

1.6 Overview of the Thesis

Chapter 1 presents general view of the research in term of introduction, problem statement, objective, scope of study and significance of research.

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